Phenocrystic Texture and Morphologic Variation in K-Feldspars from Porphyritic Granite Suites in Southwestern Nigeria

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Abstract- Porphyritic granite is the commonest textural type in the basement complex of southwestern Nigeria. The preference for this type of texture and their morphological variation is investigated and reported in this article in the light of establishing a nexus between pluton's emplacement, regional structural trends and feldspar crystal shapes. The_syn-tectonic granite which outcrops in Idanre, Ikere, Ado-Ekiti and Omu-Aran forms a unique granite chain that extends over eighty kilometres in length. This granite chain together with the Lokoja granite suite forms the focus of this research. The first group assembled themselves parallel to the Ifewara Fault System located on western side of the plutons. The emplacement of Lokoja granite around mesmerizing faults might have been influenced by the tectonic evolution of the nearby Benue Trough which is a failed arm of a Triple Rift System. Localized strain structures, magmatic flow trajectories and mega fractures reveal vivid evidence of pure and simple shear in the granite chain. The curvilinear shape of the plutons and how they are assembled parallel to the NE-SW trending Ifewara Fault System copiously suggest their emplacement is structurally controlled. Exhaustive field investigation revealed features attributable to shearing while evidences from remote sensing depict an emplacement triggered by thrusting, followed by penetrating deformation of the country rocks. The phenocrysts in Idanre granite are rectangular, those in Ikere-Ado granite suites are spherical while those from Lokoja granite are generally oval to elliptical. Morphologic variation in these orthoclase feldspars possibly resulted from both regional and local stress regimes. The phenocrysts in these granite suites developed in two stages. An early stage of nucleation of the K-feldspars, and a later stage in which smaller grains of other minerals (quartz ± hornblende ± mica) wrapped themselves around already crystallized feldspar phenocrysts during wide-spread Pan-African magmatism.

Index Terms- Porphyritic granite, granite suite, Ifewara Fault System, shear, granite chain, Pan-African magmatism

I. INTRODUCTION

Granite in the basement complex of Nigeria which essentially composed of quartz and feldspar sometimes contain additional minerals like mica, hornblende, or both; even in rare cases, tourmaline occurs as an accessory mineral. Feldspar which forms a vital component of the granite is of two types; those containing potassium (orthoclase/K-feldspar) and those containing sodium and calcium called plagioclase. Orthoclase which is one of the components and most abundant rock-forming mineral in the crust of the earth often grow into large well-formed crystals in coarse-grained felsic rock like granite pegmatite. Granite with large crystals (phenocrysts/porphyries) of orthoclase enmeshed in fine grain matrix of other minerals is the commonest type in Nigeria basement and this makes this granite phenocrystic /porphyritic. When magma solidifies (Bowen's Reaction Series), feldspar crystallizes before quartz giving it ample chances to form large crystals during earlier crystallization phase. Consequently, quartz crystals squeeze themselves into the remaining spaces making them smaller and irregular in shape. Globally, granite research has established that a petrologic link exists between granite and rare-metal pegmatites (Thomas and Davidson, 2013; Adekeye and Adedoyin, 2007; London, 2008; London and Morgan, 2012; Goodenough *et al*. 2014). Even though, granite research has gained global relevance; yet, previous research did not report why there are geometrical variations in K-feldspar phenocrysts from porphyritic granite suites in Southwestern Nigeria. Pinotti *et al*. (2006, 2016) believed granite plutonism is mostly influenced by regional strain fields connected with structural discontinuities and shed light on their role when small plutons and large batholiths are formed. The authors emphasized that the final geometrical assemblage and their characteristic textures are complex record of their construction and internal flow history. In this paper, the authors investigate the emplacement scenarios surrounding some Nigeria granite in connection with stress fields imposed by underlining structural fabrics in the basement. In addition, we present how phenocrystic texture develops and becomes popular among Nigeria granite and how this phenomenon explains the geometrical variation among K-feldspar porphyries from three granite suites (Idanre granite complex, Ikere-Ado-Ekiti granite association and the Lokoja granite suites) in southwest Nigeria.

II. ORIGIN OF GRANITE (A REVIEW)

Formation of granite begins with partial melting of rocks at elevated temperature to produce a silicate liquid whose composition is equivalent to granite itself. The partially molten rock matter (magma) is collected together, and the buoyant magma moves upward towards the upper continental crust. Finally, space is provided for the silicate melt to form a pluton. The sequence of events is termed generation, segregation, ascent, and emplacement respectively. After making space for itself, the granite liquid begins to dissipate its heat continuously into the surrounding rocks until it fully crystallizes. This list of successive processes in granite formation particularly those of batholithic dimensions could span millions of years (Pitcher, 1993). For partial melting to be accomplished, Thompson (1999) believed the conventional increase in temperature with depth at 20°C/km could not generate the heat in excess of 800°C to melt common crustal rocks at 35 km depth. Thus, Snelling (2008) revealed that apart from geothermal gradient, water content of the magma, pressure, and underplating (heat from mantle-sourced basaltic magmas) are crucial to melt generation particularly at shallow crustal levels. Even though, the mechanism of ascent of granite magma through the crust has not been fully understood; however, transport through fractures (e.g., Brown, 2004; Weinberg and Regenauer-Lieb, 2010), shear zones (e.g., Hutton and Reavy, 1992; Rosenberg, 2004), or strain-controlled conduits (e.g., Brown and Solar, 1998a, 1998b, 1999; Weinberg, 1999) are among the commonest. The old idea about how buoyant granitic magma rises through the upper crust as bulbous (diapiric) masses (Weinberg and Podladchikov, 1994) has been substituted by models involving ascent through narrow channels such as dikes (Clemens and Mawer 1992; Clemens et al. 1997), faults (Petford et al. 1993), or expansive structures (Collins and Sawyer, 1996; D'Lemos et al. 1993). Snelling (2008) believed the advantage of these models over the diapiric concept is that transporting very large volumes of granite magmas through the upper crust (Marsh, 1982) is easier as severe thermal and mechanical barriers connected with such transfers are eliminated. Snelling (2008) believed it explains the interrelationship between granite magmatism and silicic volcanism. Magma emplacement is the stage when silicate melt form plutons in the lithosphere. Soon after emplacement, the granite magma starts to lose heat to the surrounding rocks and crystallization begins. One question which has largely remained unanswered is how long it takes granite plutons to cool after their emplacement. Clemens (2005) stated that it is possible to model the cooling granitic plutons by conduction (Carslaw and Jaeger, 1980) particularly if it is tabular or sufficiently thin. However, Snelling and Woodmorappe (1998), and Snelling (2008) thought crystallization and cooling of many granitic plutons take place much more rapidly. This spontaneous and rapid process is triggered by convective heat transfer associated with circulating hydrothermal and meteoric fluids (Norton, 1978; Spera, 1982). During crystallization and cooling, the huge amounts of water associated with granitic magma is released into the country rock thereby precipitating excessive pressure which facilitates fracturing (Knapp and Norton, 1981). As the host rocks absorb water and heat from the cooling pluton, the increasing fluid pressure in pore spaces of the host rock triggers fracturing (Knapp and Knight, 1977), which pushes the pluton's heat further into the new cracks. Crystallization progresses due to irreversible heat loss from the magma to the surrounding rocks (Candela, 1992). This heat loss progressively shifts the solidus boundary continually into inner parts of the intrusion (Candela, 1991) until the last crystal at the centre of the pluton solidifies. Snelling (2008) believed, following experimental studies (Winkler and Vön Platen, 1958; Swanson et al. 1972; Dingwell et al., 1993; Wampler and Wallace, 1998) that it is misleading to suggest that crystallization of phenocrysts in granite is by slow cooling. Swanson (1977); Swanson and Fenn (1986) revealed that minerals in igneous rocks can start crystallizing and grow rapidly to requisite size from a granitic melt based on experimental studies. Clemens (2005) provided answers on how long it would take plagioclase crystals in a particular granite to form. The author reported based on experimental linear crystal growth rates of quartz and feldspar that the growth rates of $10^{-6.5}$ m/sec to $10^{-11.5}$ m/sec are common. Clemens (2005) interpreted this to imply that a 5 mm long crystal of plagioclase could grow within one hour, but probably less than 25 years. Marsh (1989) revealed it is actually not the rate of mineral growth that constrains crystal size in igneous rock like granite but extraneous geologic factors. Lofgren (1980) and Tsuchiyama (1983) demonstrated that the rate of nucleation is more relevant to growth rates and crystal sizes. Thus, London (1992) based on experimental studies, argued that gigantic crystals of feldspar found in granite pegmatite could have developed within a few years. Furthermore, Snelling and Armitage (2003); Snelling (2005, 2008) reported based on radio-halos that cooling of large crystals often take few days or weeks at most.

III GEOLOGICAL SETTING

A. Regional geology

Nigeria lies within Pan-African mobile belt which evolved by plate tectonic processes involving collision of passive continental margin of West African craton and active margin of the Tuareg shield about 600 Ma (Kennedy, 1964; Burke and Dewey, 1972; Turner, 1983; Liégeois et al. 2003; Adetunji et al. 2016). The belt which extends over several thousand kilometres in length and hundreds of kilometres in width is made up of a northern section comprising the Pharusian belt, LATEA (Laouni, Azrou-n-Fad, Tefedest, and Egkrk-Aleksod), (which form parts of a single passive margin in central Hoggar) micro continent and Eastern Hoggar (Liégeois et al. 2003) (**Fig. 1**) and a southern segment comprising the Benin-Nigeria Shield (The Dahomeyide) which contain numerous blocks that merged together during an oblique collision (Ajibade and Wright, 1989). The section of this belt that falls within Nigeria (The Nigeria Shield) is popularly called the basement complex. South-western Nigeria which constitutes one of the large areas where the basement complex is exposed is underlain by migmatite-gneiss, low-grade metasediments (schist belts), and Pan African granites (Ajibade et al. 1987; Rahaman, 1988; Dada, 2008) (**Fig. 2**).

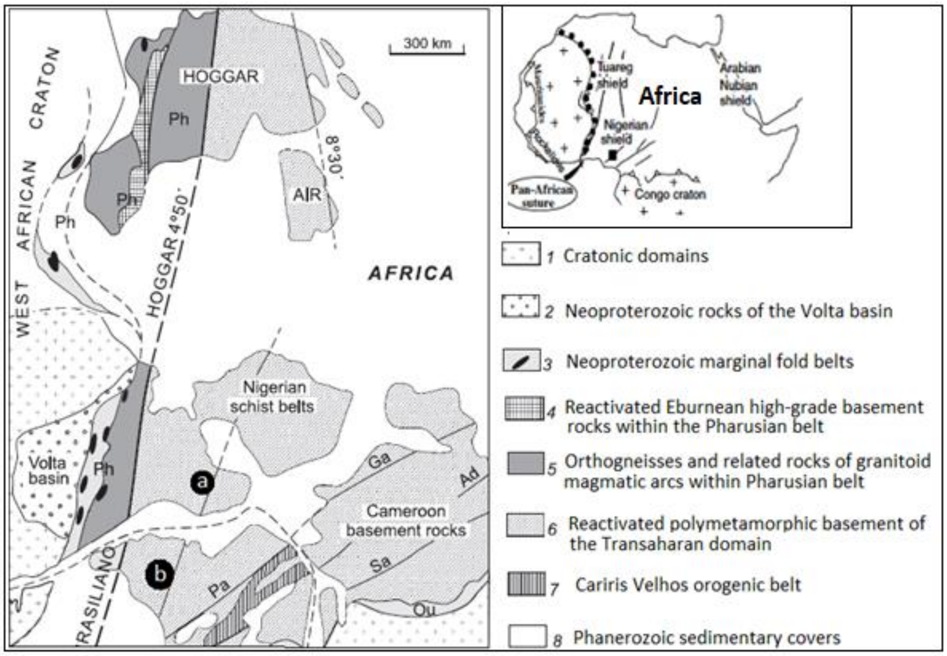

Fig. 1: Schematic tectonic framework of the Pan-African Province, the geological components and main lineaments (shear zones). Pa (Patos); a (Ile-Ife); b (Senador Pompeu); Ga (Garoua); Ad (Adamaua); Sa (Sanaga); Ou (Oubanguides). (Modified after Trompette, 1994; Kröner and Cordani, 2003; Liégeois et al. 2003; Adeoti and Okonkwo, 2016).

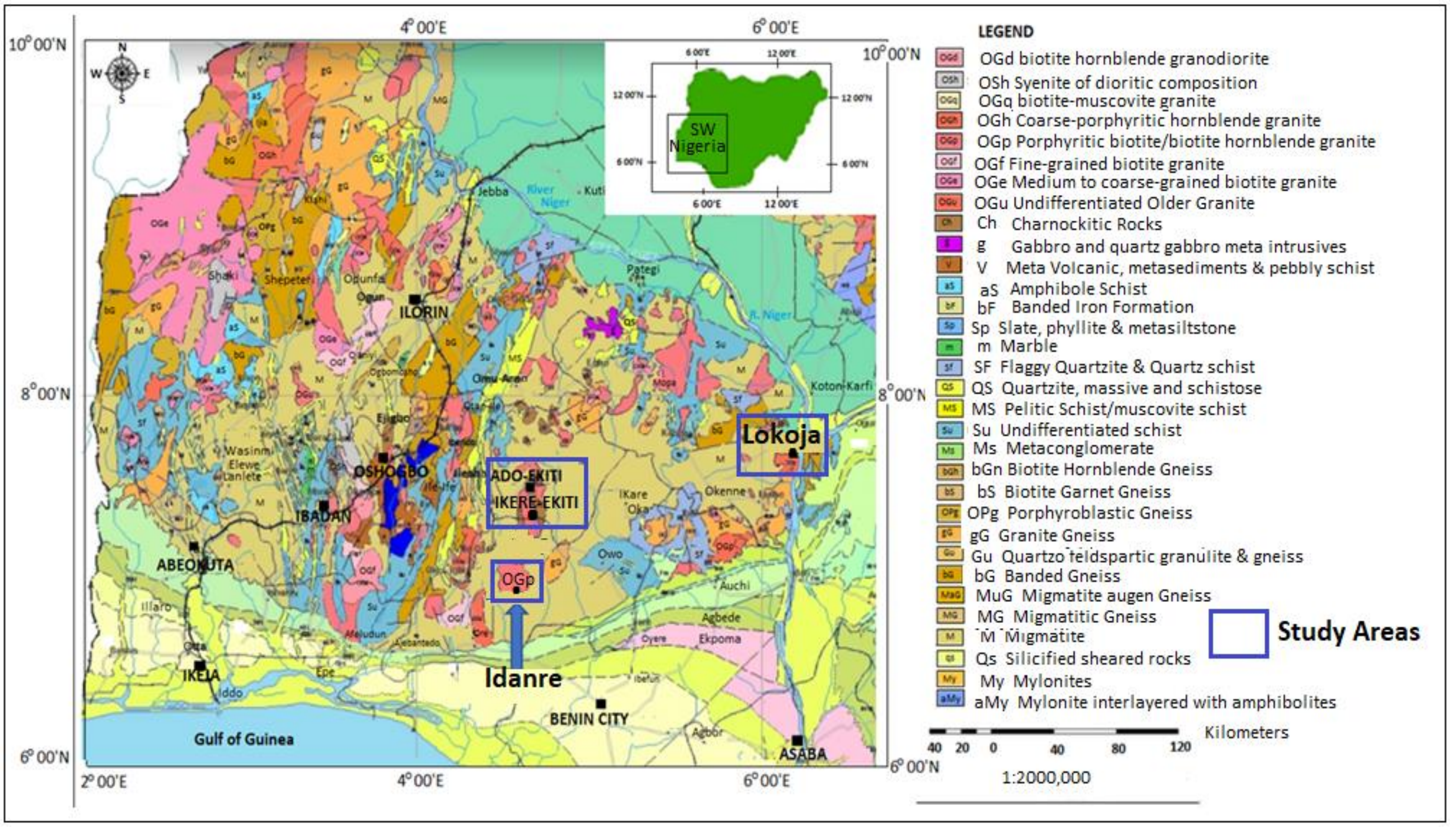

Fig. 2: Generalized Geological map of South-western Nigeria showing the location of the study areas (GSN, 1994).

These older assemblages are intruded by undeformed acidic and basic dykes. The Migmatite-gneiss complex is an assemblage of migmatitic rocks and gneisses which grades into each other. This relationship, coupled with similar evolution and structural histories made many workers to consider migmatitic-gneiss-quartzite rocks as a single unit. Oluyide et al. (1998) believed the unit originated from Pan-African tectono-thermal activities which acted on diverse lithologies after they were harmonized by widespread migmatisation, extensive metasomatism and magmatism. The schist belts occur in discrete belts that are more prominent in western part of Nigeria. The granite, popularly called ‘Older granite’ in Nigeria occurs as batholiths and plutons across the entire basement terrain. The granite units are deeply-rooted intrusive bodies emplaced into the continental crust during Pan-African orogeny. This phenomenon suggests why some authors prefer the name ‘Pan-African granites’ as they are products of widespread magmatic activity across African continent around 600 Ma. These rocks, though commonly called granite, vary slightly in texture, mineralogy and chemistry. Reports from previous researchers (e.g., Truswell, 1960; Kayode, 1976; Olarewaju, 1978; Rahaman, 1988) revealed the unit embrace diverse rock types including syenite, granodiorite, adamellite and true granite. Specifically, they are biotite-granite or hornblende biotite-granite which forms conspicuous outcrops that are quite distinctive. Even though, granite is generally plutonic; however, the texture of Nigeria granite varies from coarse-grained, medium-grained, fine-grained to porphyritic types. These rocks occur in suites with distinctive morphology while their composition, age and structural evolution distinguishes them from the anorogenic ring-dyke complexes of north central Nigeria which are called the ‘Younger granite’

B. Local Geology

Porphyritic granite is common in Idanre (**Fig. 3a**), Ikere, Ado-Ekiti area (**Fig. 3b**) and Lokoja (**Fig. 3c**) among others and granite from these three localities form the focus of this study. Idanre has the highest population of granite in southwestern Nigeria (Akinola, 2020) for which it is a UNESCO World Heritage Centre. The dome-shaped masses are distinctively visible in all panoramic views of the town (**Fig. 4**). Ikere and Ado-Ekiti area on the other hand contains massive granite outcrops concentrated within peripheral zones of Ikere-Ekiti town and it stetches along northern direction into neighbouring Ado-Ekiti metropolis. Granite in these localities have whale-back appearance with steep slopes (**Fig. 5**). The granite outcropping in Ikere-Ekiti covers approximately 20 km in length. Thus, forming prominent topographic features of Ikere-Ekiti and Ado-Ekiti. Specifically, the towering inselbergs have coarse to porphyritic texture. The suites which exhibit slight compositional variation are mainly biotite granite; while other smaller plutons are predominantly hornblende biotite-granite. The granite forms two notable hills (the Orole Hill and Olosunta Hill) located within outskirts of Ikere-Ekiti town. The elevation and steep slopes of these non-vegetated masses has enchanting and alluring touristic attractions. Lokoja is a town on eastern margin of the basement complex of southwestern Nigeria. Granite in Lokoja area occurs as residual hills of average heights, they are typically disaggregated by weathering but with good exposures and gentle slopes that allow geological investigations. Granite in Lokoja area occurs along Agbaja Plateau Road (**Fig. 6)** and around Salem University Campus, Lokoja.

IV. GEOLOGICAL STRUCTURES AND GRANITE EMPLACEMENT

Structures are essential in magma migration and how the granite provides space for itself within the crust. From zone of partial melting of the source rocks to the intrusive phase, melt migration is accomplished through interconnected system of discontinuities such as fractures, dikes and sills which often have dispersive contacts with the host rocks (Toe et al., 2013). Consequently, the structures born by granite plutons often reflect the emplacement scenarios surrounding the introduction of silicate melt into the country rocks as it provides information about regional stress field around the granite intrusion. Literature search revealed paucity of structural data on Nigeria granite; however, technical profile of many plutons around the world offered specific conditions of granite emplacement. Hutton, (1996) in his article ‘the space problem in the emplacement of granite’ specified that “*a single simple underlying theme may be that granite is fundamentally syn-tectonic and occurs mainly in orogenic settings*”. The author, drawing specific examples from literature revealed granite emplacement that are associated with tectonic structures include: those located along transcurrent structures, extensional structures and those involving thrust and high-angle reverse faults. Specifically, Hutton (1996) revealed that the Rehamma alkaline granite of Morocco (Lagarde et al., 1990) is situated along western Meseta shear zone; The Mortagne pluton, France (Guineberteau et al., 1987) is locked within the south Armorican shear zone. While the Strotian Granite, Scotland (Hutton, 1988a, 1988b) is located adjacent to the Great Glen Fault, the Main Donegal Granite, NW Ireland (Hutton, 1982) and Quernetoq pluton (Hutton et al., 1990) are emplaced along extensional shear zone.

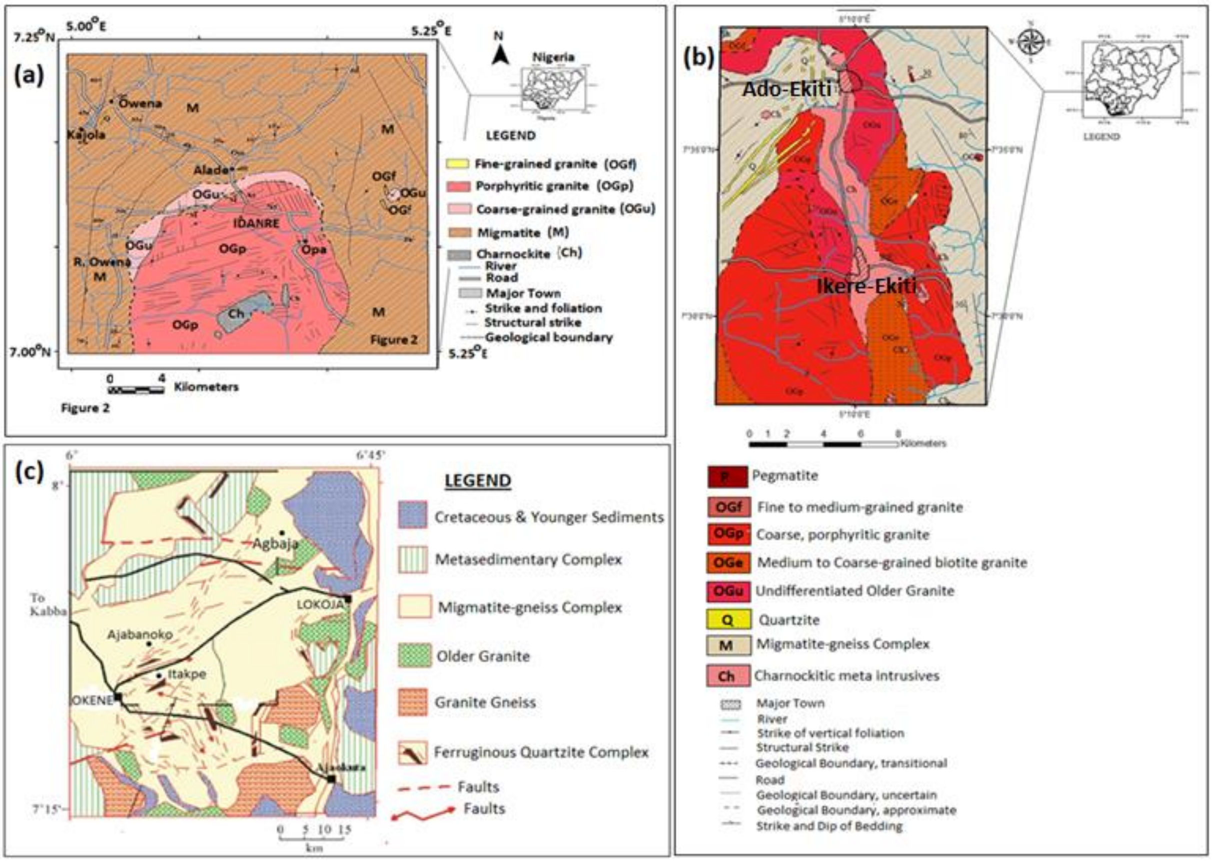

Fig. 3: More detailed Geological map of (a) Idanre, (b) Ikere-Ado-Ekiti area and (c) Lokoja area

Fig. 4: Panoramic view of Idanre town surrounded by towering porphyritic granite (inset: rectangular phenocrysts of the Idanre porphyritic granite).

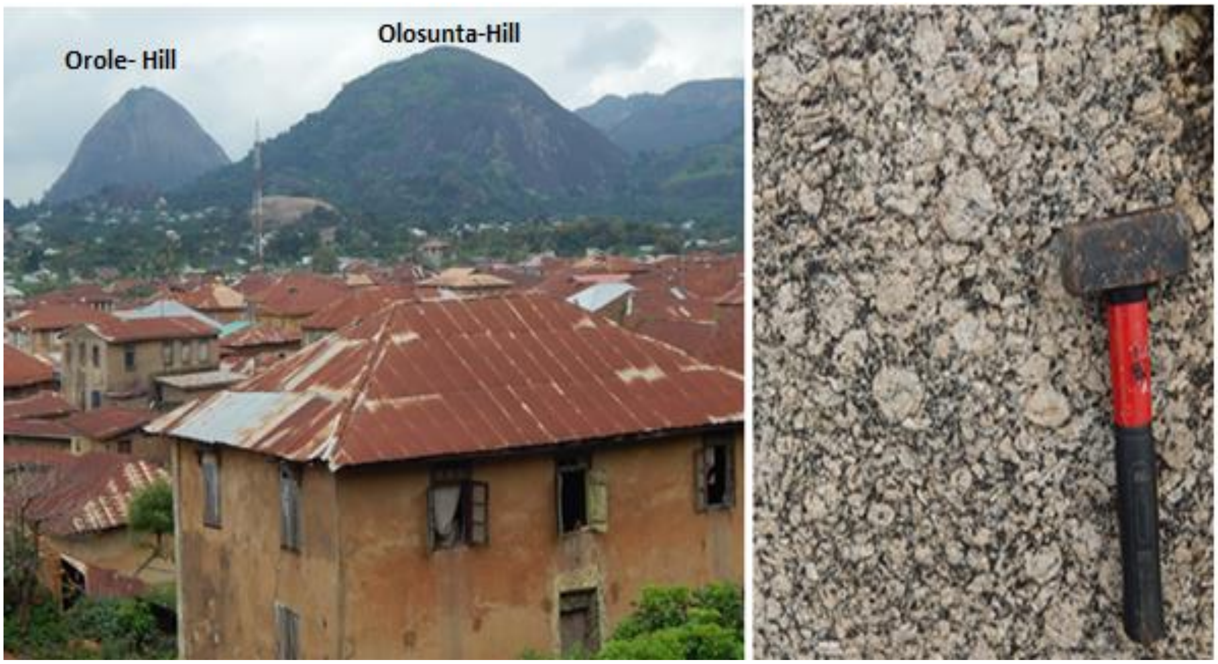

Fig. 5: Panoramic view of Ikere-Ado-Ekiti granite with steep slope (inset: rounded phenocrysts of the rock).

Fig. 6: Outcrop exposure of porphyritic granite from Agbaja- Plateau Road in Lokoja area. The orthoclase phenocrysts in the rock (right photograph) are oval in shape.

A. The Idanre granite batholith

Analysis of structures associated with the Idanre granite batholith (Anifowose and Kolawole, 2012) revealed fractures align themselves along the long axis of the batholith. Thus, the authors discovered this probably signify zones of discontinuities within the host migmatite basement. The duo believed these zones of weakness may have been imposed by flow mechanisms of the rising magma. This assertion supports previous works (Oluyide, 1988) suggesting such features control the emplacement of the plutons. Anifowose and Kolawole, (2012) following Read and Watson, (1962) emphasized that discordant forceful intrusions often obliterate pre-existing structures by imposing on the host rocks new sets that are attributable to hydrostatic pressure of the magma. The authors envisaged steep dips and intense folds on migmatite-gneiss on a segment of the Idanre batholith suggesting the granite intruded into the ancient basement at great depth causing penetrating deformation of the country rocks at the periphery of the intrusion. The authors revealed, the western side of the batholith exhibits lower intensity of deformation which diminishes abruptly towards the granite gneiss around Owena River; while the eastern flank is characterized by deformation effects which lessened as one moves gradually away from the intrusion. Furthermore, the authors revealed, based on general axial direction, that the Idanre batholith suffered compression along E-W direction symbolizing maximum principal compressive stress ($\sigma1$) direction. This compression may represent Pan-African tectono-thermal effects during which the general strike of Nigerian basement was set in N-S direction (Rahaman, 1976). The intermediate principal compressive stress direction ($\sigma2$) represents the vertical (ascent) direction while $\sigma3$ represents minimum principal compressive stress direction. Anifowose and Kolawole, (2012) reported that $\sigma1$ and $\sigma3$ stress directions correspond to the two significant fracture sets observed on the Idanre batholith (**Fig. 7**). Discontinuities which are aligned parallel to $\sigma1$ tend to be more open (Anifowose and Kolawole, 2012; Meijerink, 2007). Most times, the structure of an igneous body and its surrounding rocks reflect the emplacement history of the intrusive phase and how the pluton crystallized. Crucial are the primary structures which is synchronous with crystallization, these includes magmatic flow structures which aid the discernment of mineral alignment and xenoliths orientation. Accordingly, as a rule, these primary structures align themselves parallel to the roof and walls of the intrusion. Such structures are approximately inclined tangentially to the direction of upward and outward movement of the magma and these flow lines (the fracture sets aligned in NNW-SSE, NNE-SSW direction) mark the direction of extension due to this magmatic pressure (Read and Watson, 1962; Anifowose and Kolawole, 2012). Variation in tonal signature of satellite image and exhaustive field geological investigation coupled with abrupt change in grade of migmatization of the rocks on opposite banks of River Owena further confirmed the presence of a major fault which control the direction of flow of the major river (Anifowose and Kolawole, 2012). A closer view of the satellite image, the authors emphasized, showed that Idanre batholith is fault-bound while the longest fracture which cut the batholith and host rocks probably suggests the batholith intruded a network of pre-existing fault blocks in the country rock.

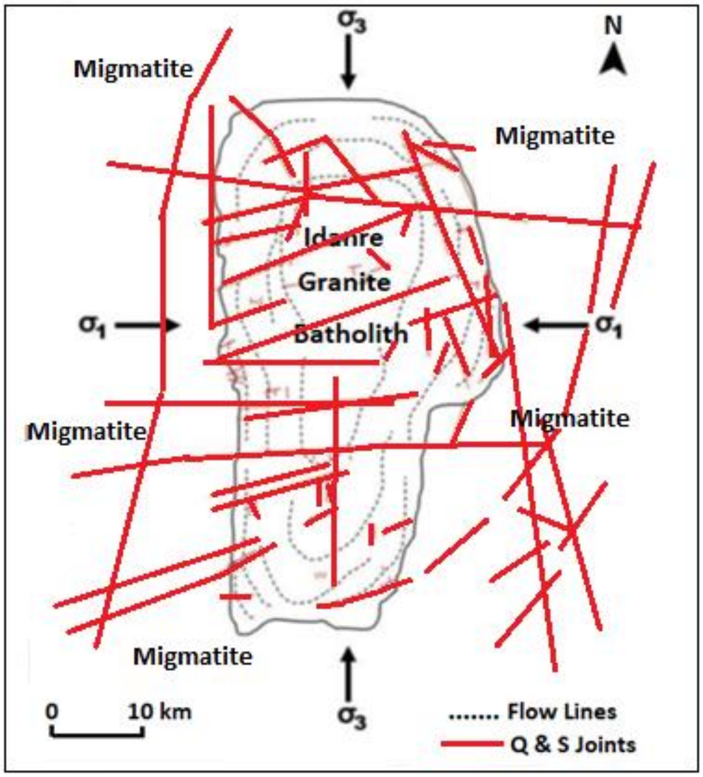

Fig. 7: Megastructures related to strain, magmatic flow trajectories and emplacement fractures in Idanre Batholith (redrawn after Anifowose and Kolawole, 2012). $\sigma1$ represents extensional fracture direction, $\sigma3$ is pure shear direction, other directions represent simple shear (Illustrations are after Oden, 2012).

B. The Ikere-Ado-Ekiti granite Suites

Whether the Ikere-Ado-Ekiti granite emplacement was triggered by regional structural trend depends on the shape of its pluton or batholith. The low-lying fine-grained granite in the vicinity of these massive bodies exhibits parallel fractures that are oriented along N-S direction (**Fig. 8**) which possibly represent unequivocal evidence of shearing. Coincidentally, these fractures are aligned along the long axis of the granite suites. Thus, the granite plutons may have arranged themselves parallel to this shear zone or another set of linear structures that are possibly not exposed at the surface. More importantly, the location of granite plutons parallel to NE-SW trending Ifewara Fault System (**Fig. 9**) located towards western side of the granite-charnockite association clearly support the granite emplacement may have been structurally controlled. Although, Kolawole and Anifowose, (2011) were first to suggest based on exhaustive field studies that the granite suites in Ikere-Ado-Ekiti area probably represents an extension of a granite-charnockite association that started from Idanre in Ondo State extending into Omu-Aran in Kwara State. The emplacement of this granite masses along a north-south direction (Olarewaju, 1987), the curvilinear shape of the granite units, the similar geochemical characteristics (Akinola, 2020) and geochronological data of the charnockite (Akinola et al. 2021) particularly reflect they are comagmatic. Thus, supporting the background fieldwork which suggested they probably represent lateral continuation of the Idanre granite complex. Although, this deep-seated regional discontinuity which extends into northern Nigeria has been mentioned in literature as only been recognised on satellite image but detailed study of the fault was not undertaken (Ananaba and Ajakaiye, 1987). However, more recent works (Anifowose, 2004; Kolawole and Anifowose, 2011; Adeoti and Okonkwo, 2016) revealed that evidences of the Fault manifested in shearing of rocks around Iwaraja-Ifewara areas near Ilesha. Previous researchers (e.g., Ajayi, 1981; Rahaman, 1988; Elueze, 2000; Kröner and Stern, 2005) supported this by indicating that Ilesha area is located on eastward-dipping subduction zone based on ophiolite and mantle diapirs which represent remnants of an ocean sheet (Tethys Sea) which closed during the Jurassic (170 Ma). The emplacement of these granite suites may have been controlled by a combination of mechanical interactions of this pre-existing regional fracture (Fault) and a subduction-related tectonic setting. However, Vigneresse (1995) believed granite plutons aligned parallel to extensional direction shows shearing. Following the Andersonian theory of fractures, Vigneresse (1995) thought that a pluton emplaced into inelastic crust often have roots aligned with the direction of maximum compression.

Fig. 8: A fine-grained granite with parallel fractures that are oriented N-S in the vicinity of massive porphyritic granite bodies in Okeyinmi area, Dalimore, Ado-Ekiti.

C. The Lokoja granite Suite

Lokoja is a nodal town connecting north, east and southwestern Nigeria. It is located near the confluence of River Niger and Benue. Geologically, it is located on a transitional zone between the basement complex of southwestern Nigeria and the sedimentary sequences of Lokoja Basin. The emplacement of granite around this vicinity may have been lately affected by the tectonic evolution of nearby Benue Trough which is a failed arm of a Triple Rift System. The Benue Trough which forms major part of the basin that lies on eastern side of the basement complex has a structural evolution that is connected with the separation of Africa Continent from South America during Jurassic (170 Ma) period.

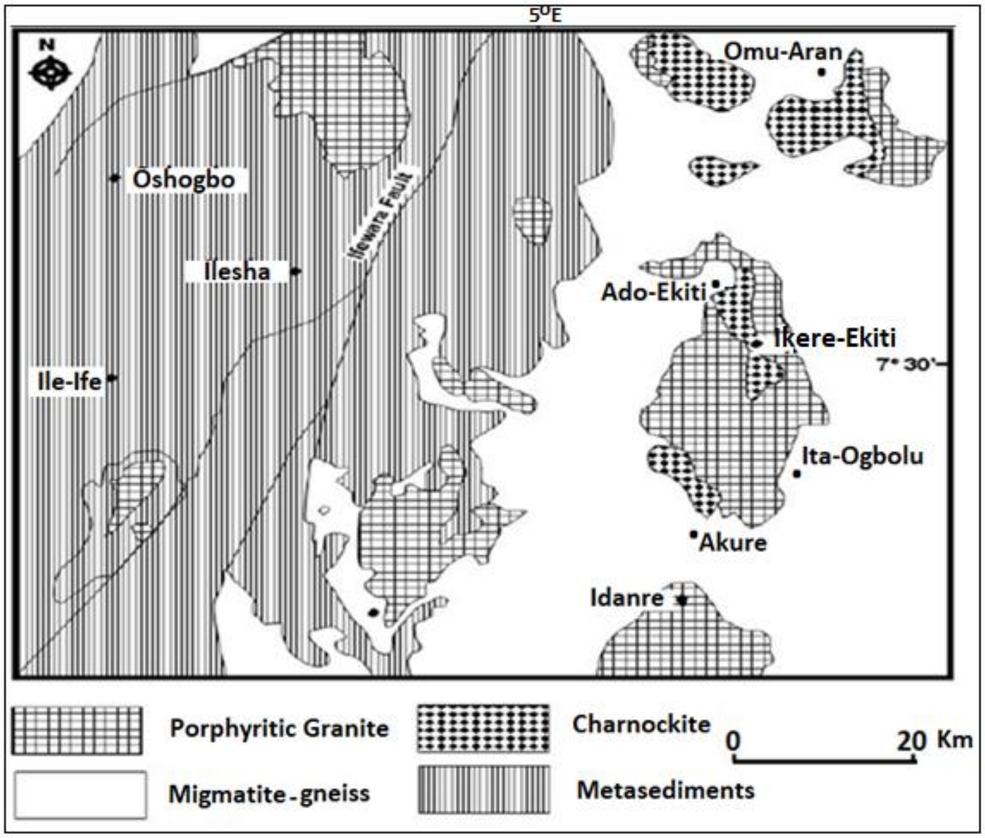

Fig. 9: Northern prolongation of the granite-charnockite association extending from Idanre through Ikere-Ado-Ekiti area into Omu-Aran in the north. The plutons assembled themselves parallel to the Ifewara Fault System towards the west (after Odeyemi et al. 1999; Kolawole and Anifowose, 2011).

Kröner and Stern, (2005) have associated the occurrence of accretion prisms, ophiolites, magmatic suites of island-arc origin, high-pressure metamorphic assemblages, paleo-oceanic crust and mantle diapirs of basic to ultrabasic affinities with commencement of ocean opening which preceded collision-related subduction processes in the area around 710 ± 190 Ma. Furthermore, the duo suggested that, several terranes with different rock units further south of the Tuareg Shield were associated with ocean closure in a collision belt which produce Pan-African rocks tectonically related to ocean crust and interlayered with older basement units. Kröner and Stern (2005) also believed the ancient terrain assemblages were warped and strongly distorted when the basement drifted westwards to collide with the edge of West Africa craton. This distortion and drifting precipitated crustal thickening that triggered terrain reactivation, deformation of the Mesoproterozoic schistose assemblages and eventual emplacement of the granitoids (McCurry, 1976). Even though, paucity of structural data on Nigeria granite may have hindered a generalized evaluation of the synopsis of regional connection with granitoids in other parts of the basement complex. However, a close examination of how the plutons is assembled revealed the granite in Lokoja area is confined within mesmerizing fault domains. This may indicate they are nucleated within specific areas of structural weaknesses. The organization of the plutons parallel to the course of a major river along Agbaja Plateau Road and those that dotted the river channel around Salem University may indicate the flow pattern of these rivers is structurally controlled. More importantly, the association of Lokoja granite with major faults that extends westward from Agbaja Plateau, and another from Agbaja to Ajabanoko towards southwestern part of the area, and parallel faults that appear to wrap around Itakpe and Okene towns (**Fig. 3c**) reflects that the area is prone to faulting and may have affected granite emplacement in the area.

V. DISCUSION

One of the strange features of porphyritic granite that has not been pointed in earlier research or explain satisfactorily is how the shape of phenocrysts of orthoclase feldspar vary among granite suites in southwestern Nigeria. This could mean evolution and certain basic or fundamental ideas about granite's origin in Nigeria are not fully conceptualized. One principal challenge in this regard is that granite plutonism takes place deep within the earth. So, the process is obscured by the thick overburden (crust) above them. Furthermore, the granite we see at the surface of the earth today might have been several kilometres deep within the crust before erosion exposed them. After exposure, the evidences of crystallization must have been lost, probably several million years before the first geologist visits the outcrop. Even though, experimental studies using phase diagrams have improved our knowledge about how rocks are formed. However, among the basic concepts to understand is how porphyritic textures develops in granite during magmatic crystallization. Porphyritic texture probably develops in two stages, an early stage characterised by formation of orthoclase feldspar in deeper levels within the crust. At this stage, the magma has a heat component similar to the melting temperature of the protolith; hence, the crystals of orthoclase are well-ordered, stable and large enough. When the crystallizing silicate melt moves up further towards the Earth's surface, the already established orthoclase grains gather more materials from the melt to grow bigger and firmly take their spaces as partially solidified masses. After the partially solidified orthoclase feldspar grains are pushed upwards towards the surface by the buoyant magma, the temperature must have been sufficiently low to allow quartz to start crystallizing. At this stage, it is only the spaces available which are actually smaller that are now taken up by quartz grains during late phase crystallization. As the magmatic body solidifies further, the texture now is such that the early crystallized phase (orthoclase) forms the coarser grains (porphyries) that are surrounded by smaller quartz grains thereby forming a porphyritic texture. All the granite suites under investigation are of the 'Older granite' series in Nigeria and are exclusively Pan-African. So, all the units are affected by the Pan-African tectono-thermal event because they evolved within the same age bracket and tectonic setting. For this, the granitoids are expected to exhibit similar features particularly with respect to the shape of their phenocrysts. However, field investigation revealed phenomenal discrepancies in the shapes of K-feldspar porphyries associated with these granite suites. This possibly suggests local structure supressed the regional structure; otherwise, the shape of phenocrysts in Idanre and Ikere-Ado-Ekiti porphyritic granite which developed under similar regional structural stress regimes should have exhibited similar shapes. Phenocrysts in Idanre granite is rectangular in shape (**Fig. 3** [inset]) while that of Ikere-Ado-Ekiti area is rounded or circular (**Fig. 4** [inset]) and those from Lokoja granite are oval in shape or flattened (**Fig. 5**). The structure of the latter takes semblance of porphyroblasts in augene gneiss. Although, the emplacement of these granite units showed copious evidences of structural control; however, the suites in the different localities have different stress fields associated with their emplacement tectonics as recorded in the schistosity of the surrounding rocks (Hanmer and Vigneresse, 1980; Paterson and Fowler, 1993). The effects of the stress regime manifested in shapes of the porphyries of orthoclase feldspar. Furthermore, the evidence of this variation is reflected in the size and shape of mafic enclaves (xenoliths) of the country rocks which symbolizes the magnitude of local stress associated with each emplacement. The margins of Idanre granite have huge and irregular xenoliths which may mean the emplacement is rapid, spontaneous and catastrophic. As indicated in a previous work, Anifowose and Kolawole, (2012) emphasized that the batholith is compressed along E-W direction, so, the rectangular shape of the feldspar porphyries in Idanre granite complex may be attributable to the longer axis of the rectangular phenocrysts being oriented N-S while the crystals are yet to solidify fully. Phenocrysts in the Ikere-Ado-Ekiti granite are circular in shape, meaning they are probably affected by a combination of local and regional stress regime where σ1 which represents extensional fracture direction and σ3 is pure shear direction almost balance out.

VI. SUMMARY AND CONCLUSIONS

Phenocrysts in porphyritic granite from granite suites in Southwestern Nigeria are morphologically different. These variations are investigated to find out if there is any nexus between structural evolution, stress regime that characterizes the granite emplacement and the shape of the phenocrysts. From the research, the following conclusions are reached.

1. The curvilinear shape of the granite bodies may indicate their emplacement is structurally controlled. Evidences from remote sensing and exhaustive field investigations revealed high concentration of fractures which possibly connote extensive shearing of the host rocks. In the granite, it also symbolises shrinkage effects triggered by compression during magma ascent. Mafic enclaves (xenoliths) of country rock in the granite suites around Idanre and Ikere-Ado-Ekiti probably suggest the granite origin was not ultrametamorphic, but rather, a product of forceful injection of silicate liquid into the host rocks.
2. The NE-SW trending Ifewara Fault System located towards the west and parallel to the Idanre, Ikere-Ado-Ekiti and Omu-Aran granite chain may indicate the granite masses are fault-bound as the batholiths exhibit fractures which represented zones of weaknesses and the enormous density of lineament in these batholiths reflects the direction of flow of the hydrologic system that punctuated the terrain.
3. The emplacement tectonics of the granite produced penetrating deformation in the country rocks, while the variation in shapes of the phenocrysts is tied to overprinting effect of local structures. The association of Lokoja granite with major faults that extends westward from Agbaja Plateau, and another from Agbaja to Ajabanoko in southwestern part of the area, and parallel faults that wrap around Itakpe and Okene towns reveals the area is prone to faulting and may have contributed to the emplacement of granite in these domains.
4. According to Vigneresse, (1994), structural measurements and gravity data are crucial when describing the mode of granite emplacement in various tectonic settings. Hence, to further consolidate on existing works, there may be need for detailed geophysical methods to establish a three-dimensional (3D) image of these plutons to provide adequate information on the roots, depth, and emplacement scenarios of the granite magma. Also, sufficient fabric and structural data needs to be collected to throw more light into the relationship between the granite and host rocks which is consistent with the views of Hanmer and Vigneresse, (1980) revealing that primary magmatic structures often depict interaction between pluton and its surrounding rocks.

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AUTHORS' CONTRIBUTION

First Author (**Akinola, O.O**): Initiated the research, participated in field work for acquisition of data. He wrote the body of this manuscript. The second Author (**Talabi, A.O.**) Participated in field work. He wrote the introduction, conclusion and abstract of this paper. He was responsible for the editing/formatting of the manuscript. He is the corresponding Author responsible for all correspondences. he third Author (**Aturamu**, **Adeyinka O.**) participated in the field work and draft of the manuscript. All the Authors read and approved that this manuscript be submitted to Contribution to Mineralogy and Petrology for publication.

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